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problem of a representative, or copying, function in which the mind or consciousness mirrors its objects, is to make the chemistry of carbon irrelevant to the knowledge of carbon, and to forget, apparently, that the knowledge of nature is something to be accumulated, transmitted, and used. Knowledge of nature is skill in reading the signs of nature, and a point of view which is unable to treat immediacy as the sign of causality can provide no basis for a theory of knowledge.

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THE PHENOMENA OF PERIPHERAL VISION AS AFFECTED BY CHROMATIC AND ACHROMATIC ADAPTATION, WITH SPECIAL REFERENCE TO THE AFTER-IMAGE¹

IN a recent article entitled "On the After-images of Subliminally Colored Stimuli,"² Professor Titchener and Mr. Pyle discuss certain after-images reported by Miss Thompson, Miss Gordon, and myself in a series of articles in the *Psychological Review*.³

The exact conditions under which these after-images can be obtained, as well as the correlation between them and certain related phenomena, have only recently been worked out by us and the results are as yet not published. It seems unnecessary here to discuss Professor Titchener's article in detail, since his experimental conditions differed sufficiently from ours to explain his failure to verify our results. The main variations occurred in the conditions of achromatic adaptation, in the degree of eccentricity at which the stimuli were exposed, and in the method of projecting the after-image.

One point raised by Professor Titchener, which must be discussed before we go on to our new data, is that of the variability of results at or near the outer color limits.

The method of experimentation employed in all recent zonal determinations is that of exploring the peripheral retina point by point, with a stationary stimulus and fixation and a considerable

¹ Given at the Baltimore meeting of the American Psychological Association, December, 1908.

² E. B. Titchener and W. H. Pyle, *Proceedings of the American Philosophical Society*, Vol. XLVII., No. 189, 1908, pp. 366-384.

³ *Psychological Review*, Vol. XII., 1905, pp. 386-425; Vol. XIV., 1907, pp. 122-167; Vol. XV., 1908, pp. 25-43. A monograph giving a complete statement of our results and conclusions is at present in press. This brief statement is called forth by Professor Titchener's criticism. It should be stated that the conditions referred to were given, to a certain extent, in our earlier papers. See *Psychological Review*, XIV., 1907, pp. 129-130; XV., 1908, pp. 32-33.

interval between stimuli. Professor Titchener criticizes our results, obtained by this method, because they show certain irregularities at the outer color limits. That is, at a given fixation point beyond a given degree of eccentricity, a given stimulus does not give an invariable response.

The results⁴ which Professor Titchener uses as negative evidence against us, are a set obtained for him by Professor Baird, of the University of Illinois. A study of Baird's results shows exactly the same sort of irregularity as that found in our results. For example, in the experiment to determine the limits for red with observer *B*, out of three trials with red at 68 degrees, the color was seen once as red, once as orange and once as yellow—yet 68 degrees is taken as the limit for red. Moreover, this same red was seen as yellow from 82 to 74 degrees, as orange from 72 to 70 degrees, and as red at 68 degrees in one series of tests, and in another set of tests with the same observer, was seen as gray from 80 to 70 degrees, as yellowish from 68 to 66 degrees, and as red first at 64 degrees. Thus there is a difference of 14 degrees between the points at which the stimulus is first seen as yellow in the two cases. Since Baird's results, as well as our own, show this irregularity at the outer limits, we venture to suggest that the reactions of the more peripheral portions of the retina are somewhat variable, even under carefully controlled conditions. The question is, however, one that can be settled only by an extended investigation, in which a large number of results are taken with each separate color at each of the various peripheral points. If such a series could be obtained under absolutely constant conditions of chromatic and achromatic adaptation, the results would either be entirely regular—*i. e.*, invariably the same at a given degree of eccentricity—or would, presumably, show variation in one of the two following ways: either the curve representing the number of correct judgments at each peripheral point along a given meridian would fall gradually from the point at which the color was invariably recognized, through the point at which the color was recognized in only 50 per cent. of the total number of tests, to the point at which the color was never recognized, or else the variability would be so irregular that there would be no such thing as an absolutely fixed limit for the color. In the former case the limit would be determined according to the method of liminal values, in the latter case we could only conclude that the retinal functions are variable from time to time at the more peripheral portions of the retina. We hope, in the near future, to be able to obtain a sufficiently large number of readings with a few of the standard colors to settle the question, at least in so far as these colors are concerned.

⁴ *Op. cit.*, p. 378.

Professor Titchener has suggested that the after-images which followed unperceived stimuli in our work are due to chromatic adaptation. Our reasons for not accepting this explanation of our results have already been given in an earlier paper.⁵ They are, in brief, as follows: Although the brightness and color stimuli were given in irregular order so that the observer had no clue to the nature of the stimulus, the after-image was invariably the characteristic one for the immediately preceding stimulus, and black, white, and gray were never seen as colors or followed by colored after-images. Moreover, all our work has gone to show that the after-images in question are observed under only one particular set of achromatic conditions, to be described in the following paragraphs, although there is an equal chance for chromatic adaptation to be effective throughout the entire investigation.

In general the changes which occur as the color is moved from the center to the periphery of the visual field, have been described as consisting in a tendency on the part of all colors (*Urfarben* excepted) to appear yellow or blue in the outer color zone, hence the designation of this region of the retina as the blue-yellow zone. Most of the observations on which these conclusions are based have been obtained either in the dark room, or a dark or gray background in medium illumination. Our results with the darker backgrounds agree with those already described, but under other conditions of illumination and background we have obtained very different results. Briefly, these results can be described as follows. The limits for all the colors except red and green are narrower when the colors are darkened by contrast with a white background. The most striking results (for the stimulus color) are those which show the effect of induced brightness on the color tone of red, orange, and yellow stimuli. Details can not be given here, but we can describe the situation briefly by saying that it is possible by varying sufficiently the brightness of red, orange, or yellow stimuli, to cause these colors to go through a characteristic series of changes—to wit, each of these colors can be made to appear as either of the others at almost any point on the periphery (from about 60 degrees out), and, under proper achromatic conditions, can be made to appear red at points near the outer color limits. To see orange or yellow as red it is necessary to observe them on a brightly illuminated white background, so that the colors are darkened by contrast with the background. To see red as orange or yellow it is necessary to observe it on a darker background.

Fully as striking a series of changes can be observed by projecting the after-images for blue or blue-green peripheral stimuli on

⁵ This JOURNAL, Vol. III., p. 352.

screens of different brightness values. The after-image for either of these colors is yellow on a white screen, yellow or orange on a gray screen, and orange or pure red on a black screen. The red is reported, in all cases as particularly saturated.

Darkening a green stimulus by contrast with a light background, tends to emphasize the green component of the stimulus, though the effect is much less marked than in the case of red, orange, or yellow stimuli. Moreover, pure yellow is seen as red or orange when darkened in this way, rather than as green. The after-images for red, orange, and more especially for violet, show a slightly greater tendency to appear greenish when projected on a dark than on a light background, though with no background was the effect as pronounced as in the case of the after-images for blue and green-blue. Moreover, the after-image for blue, projected on the darker backgrounds, was always red or orange rather than green.

All these results seem to show that particular brightness conditions tend to emphasize particular colors, that all colors except red and green are decreased in saturation and recognized at a lesser degree of eccentricity on a dark than on a light background, but that even red and green (whether stimulus or after-image colors) appear more saturated and are seen at a greater degree of eccentricity when viewed against backgrounds having certain brightness values.

The achromatic conditions have a direct effect on the relative frequency with which after-images follow colored stimuli at the periphery. Peripheral after-images are entirely lacking when the observations are made on a wholly darkened field (*i. e.*, in the dark room), and even in good illumination the percentage of after-images was smaller and their saturation less on the dark than on the light background. Thus there seems to be a definite correlation between achromatic conditions and the after-image. In dark adaptation the after-image is practically absent; as the illumination is increased the percentage of after-images to stimuli gradually increases and the saturation of the after-image becomes more nearly equal to that of the stimulus; finally, on the white background in full illumination, the after-image is almost invariably as saturated as, and in most cases more saturated than, the stimulus. An exception to the latter statement occurs in the case of the blue after-image for orange or yellow, when these two colors are seen as red on the white background. (The red is frequently more saturated than the blue.)

With the eye fully adapted to bright light, after-images were sometimes perceived even when the stimulus color itself was not distinguished. These after-images occurred almost exclusively when the observations were made on a white background in bright illumination. By bright illumination is meant the sort of light obtained.

as in the present experiment, from a large north window on a bright, clear day, in a room with white or gray walls. An essential condition for the after-image is that the campimeter screen be placed near enough to the window to get the full light, and not to be shadowed by the walls of the room. The results are so directly dependent on the illumination that it is necessary to work during the middle part even of bright days. These results seem to be merely another illustration of the correlation between the conditions of achromatic adaptation and the relative saturation and frequency of the after-image. They represent the typical results of one extreme of brightness adaptation, of which the opposite extreme is complete dark adaptation with its practical absence of after-images.

These after-images, which follow unperceived stimuli, occur when the local brightness conditions are such as to emphasize the color of the after-image more than that of the stimulus. For example, with the white background and white projection ground, an unperceived yellow is sometimes followed by a clear blue after-image, while under the same conditions an unperceived blue may give rise to a clear yellow after-image. In both of the cases just mentioned, the stimulus is relatively dark because of brightness contrast with the white background.

Both green and red after-images were obtained by projecting the after-images on the gray or black screen,⁶ and so observing them under the local brightness conditions which most favor the perception of red and green.

The two conditions mentioned as necessary for observing these after-images can perhaps be brought together as follows: the white background drowns out the stimulus color by darkening it beyond the point at which it is seen as color: now if the after-image is projected on a screen which emphasizes the after-image color, the result is the perception of the after-image even when the stimulus color is not seen.

The failure of the after-image in dark-adaptation seems to be analogous to the effect produced on a color by darkening it by brightness contrast with a white background. In both cases the color processes are in some way inhibited, so that one part of what seems to be, under other conditions, a reversible reaction, is lacking. With our present knowledge of retinal processes, it seems impossible to decide just how the induced brightness or the brightness of the projection ground affects the color processes. However this may be, all our results point to a direct dependence of color processes on the

⁶ For method of projecting the after-image on screens of different brightness values without changing the brightness of the general background, see *Psychological Review*, Vol. 15, pp. 27-29.

conditions of local and general achromatic adaptation, and to this *achromatic* rather than to *chromatic* adaptation as the explanation of this after-image, which Professor Titchener and Mr. Pyle have called the "paradoxical after-image."

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SOCIETIES

NINTH MEETING OF THE WESTERN PHILOSOPHICAL ASSOCIATION

REPORT OF THE SECRETARY

HISTORICALLY the meeting of the Western Philosophical Association in St. Louis, April 9 and 10, under the auspices of Washington University, was of unusual importance. For it was the semi-centennial of philosophy in the west, which claims St. Louis as its cradle. The smallness of the attendance was probably indicative of the Hegelian interest of to-day, as was the enthusiasm of those present an evidence of the permanent claims of Hegel. The numerous lunches and smokers provided by Washington University gave opportunity for more than usual discussion and fellowship among those present.

The announcement of the arrangement for publishing the larger logic of Hegel by the survivors of the St. Louis band formed a fitting testimony to the live character of the Hegelian spirit, and ought to be welcomed by students of philosophy.

The following officers were elected for the subsequent year: Professor Carl E. Seashore, University of Iowa, president; Professor G. A. Tawney, Cincinnati University, vice-president; Professor Bernard C. Ewer, Northwestern University, secretary and treasurer; with Professor A. O. Lovejoy, of the University of Missouri and Professor F. C. Sharp, of the University of Wisconsin, additional members of the executive committee.

The following members were elected: Mr. F. C. Becker, University of Illinois; Professor Bernard C. Ewer, Northwestern University; Professor C. E. Corey, Washington University; Professor Hartley Burr Alexander, University of Nebraska; Professor J. W. Hudson, University of Missouri; Professor Henry W. Wright, Lake Forest University, and Dr. Daniel A. Tear, Chicago. The following recommendations were passed: (1) That non-payment for three years shall automatically cancel membership; (2) that the time of the papers shall be printed in the program and that twenty minutes